the nighttime flow regime. In these regions, the wind flow has a large upslope component during the day. Pronounced upslope flow also is observed at Mauna Loa Observatory, on the southeastern flank of Mauna Loa, and along the Kona coast as a result of solar heating.

Wake vortices

The wake consists of two elongated counterrotating quasi-steady eddies that give rise to a wide region of strong reverse flow along the wake axis. The reverse flow extends westward from the west coast of Hawaii a distance of about 200 km. A cloud line extends along the wake axis and sometime broadens considerably farther downstream. Aerosol concentration in the southerly eddy is elevated due to the entertainment of Kilauea plume. Strong shear zones, trailing westward from the northern and southern tips of the island delineate the accelerated trade winds and air trapped in the recirculating wake.

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Dr Yi-Leng Chen
Department of Meteorology
University of Hawaii

Atmospheric Structure Around the Big Island and How It Affects Vog Flow

Relative to the size of the Earth, the thickness of the atmosphere is comparable to a sheet of Handiwrap covering a one foot diameter globe. Half of the Earth's atmospheric mass exists below 16,000 ft altitude. In short, the atmosphere is thin.

This thin layer of air is naturally divided into a number of discrete vertical regions like successive floors in a four-story building. The equivalent of the first floor within the atmosphere is called the boundary layer. In the atmosphere, air normally gets colder with height, but there are situations where the reverse is true, these regions are called temperature inversion layers. In Hawaii, the base of the boundary layer is at sea level and the top is generally in the region of 6,000 ft (~1 mile) above sea level at a strong (up to 6° C) temperature inversion. This inversion produces the top of the lowest cloud layer observed around the islands and separates the boundary layer from the free troposphere.

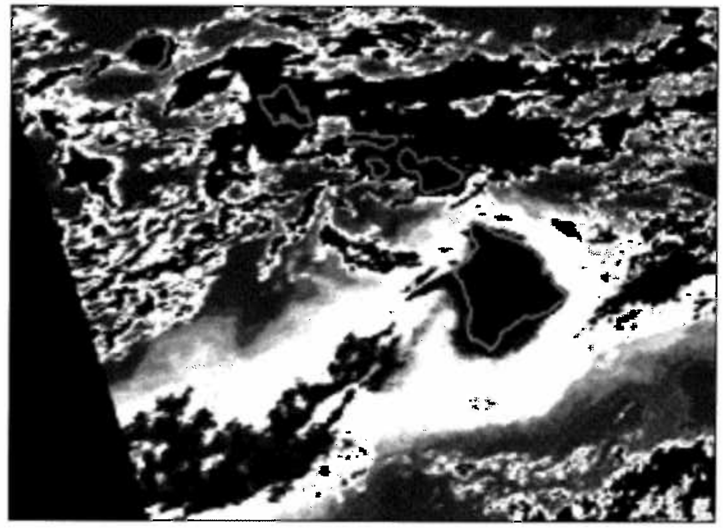
The free troposphere extends from the top of the boundary layer to another temperature inversion called the tropospause. The tropopause is usually observed at around 50,000 ft over Hawaii. Above the tropopause is the stratosphere.

The vog experienced in Hawaii is injected into the boundary layer and is for the most part trapped there. Vog, the same as clouds, is generally unable to penetrate the inversion layer; thus, the vog is carried along by the prevailing low-level trade winds from the northeast when blowing in strength. In the lee of Mauna Loa, eddies in the trade-wind flow are capable of carrying the vog along the Kona and Kohala coasts. Occasionally the vog is carried to Neighbor Islands when the boundary layer flow is other than the normal trades.

Under upslope conditions, whereby a thin layer of warm, moist boundary layer air flows up the side of Mauna Loa due to daytime heating of the dark lava, vog may be drawn into the free troposphere and carried up to Mauna Loa Observatory (11,400 ft). In so doing, the vog is pulled up the slopes from near sea level and drawn across areas not normally exposed to vog.

Dr Russ Schnell
Director
Mauna Loa Observatory
NOAA

VOG Concentrations from Satellite



An AVHRR image (2/95) processed to obtain the aerosol optical concentration. In this image, island downslope nighttime winds have pushed some of the plume to the east while the majority is being carried to the southwest by the trades which are beginning to set in. The Kilauea Volcano plume is frequent but not always present in processed satellite images suggesting emissions are somewhat episodic. This image was collected by Pierre Flament and processed by John Porter (School of Ocean and Earth Science, University of Hawaii at Manoa).

Over the past few years we have developed algorithms that can derive aerosol optical depths from AVHRR satellites. These aerosol optical depths clearly show the Kilauea vog plume as it drifts downwind from the island of Hawaii. While the AVHRR satellite is useful for case studies, it is limited by the fact that it passes Hawaii only twice a day and often sun-glint conditions prevent the retrieval of the aerosol optical depth (particularly in the summer).

In the near future, the new GOES8 satellite will come on-line. This satellite will be improved (compared to previous GOES satellites) and will have sensor digitization similar to the AVHRR satellites (10 bits over 0 to 100% albedo). Therefore, this satellite will be useful for deriving the aerosol optical depth. A particular advantage of this satellite is the fact that it is geostationary, which means it will always be looking down on the Hawaiian Islands at the same viewing angle. Instead of taking images once or twice a day, it will provide images every hour and more frequently on occasion. If successful in obtaining funding, we will be providing aerosol optical depth images from an anonymous ftp (file transfer protocol) site where users could access the images freely.

by John N. Porter
Hawaii Institute of Geophysics
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa